Characterization of Shaped Charge Jet Erosion in Drilling Mud

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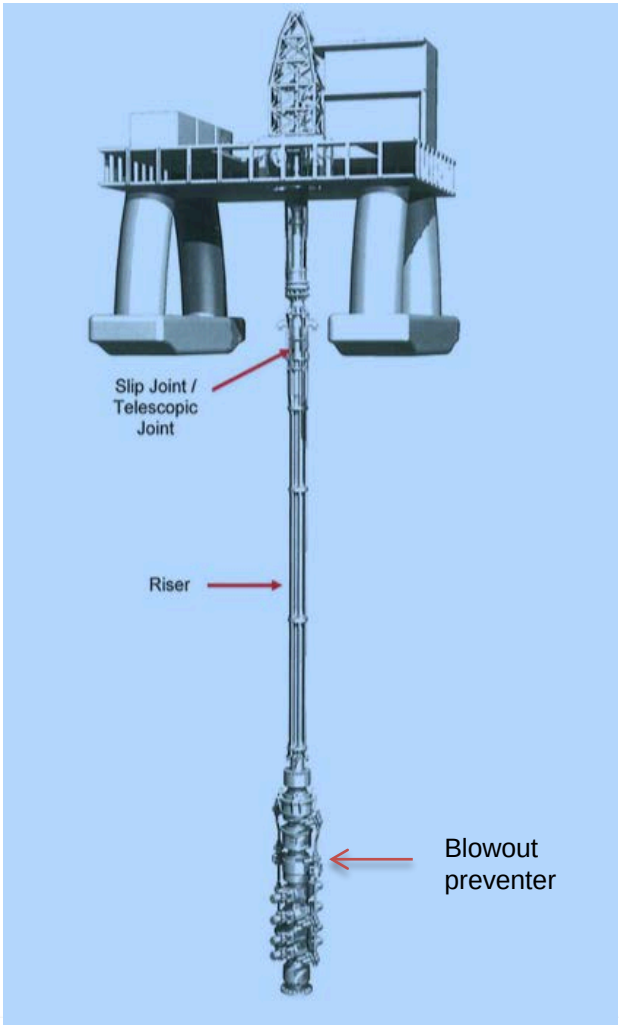
Subsea drilling practices present high consequence operational challenges

- A blowout scenario occurred in the BP/Macondo Gulf of Mexico event in 2010
- Loss of life and a drilling rig ensued
- Shell desired to design and install an Emergency Severance Tool (EST) to prevent loss of life and equipment in emergency scenarios
- An array of linear shaped charges was proposed to sever the 18.5” diam. marine riser and 9.5” diam. drill collar on command



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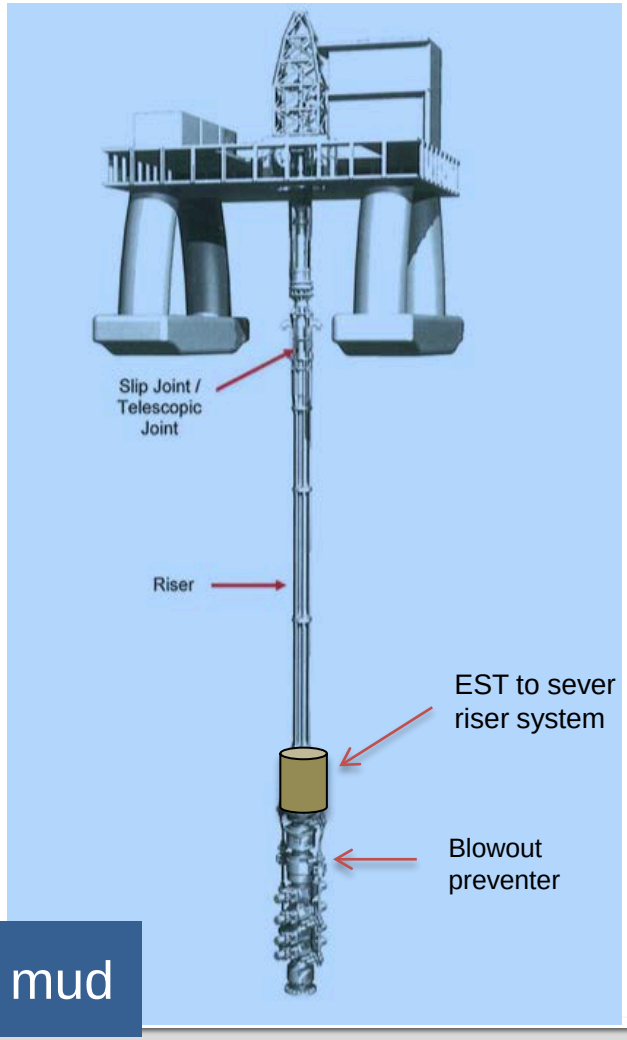
- An array of linear shaped charges was proposed to sever the 18.5” marine riser and 9.5” drill collar on command
- The charges had to penetrate successive layers of steel and up to 240mm of drilling mud (density ~ 2g/cc)

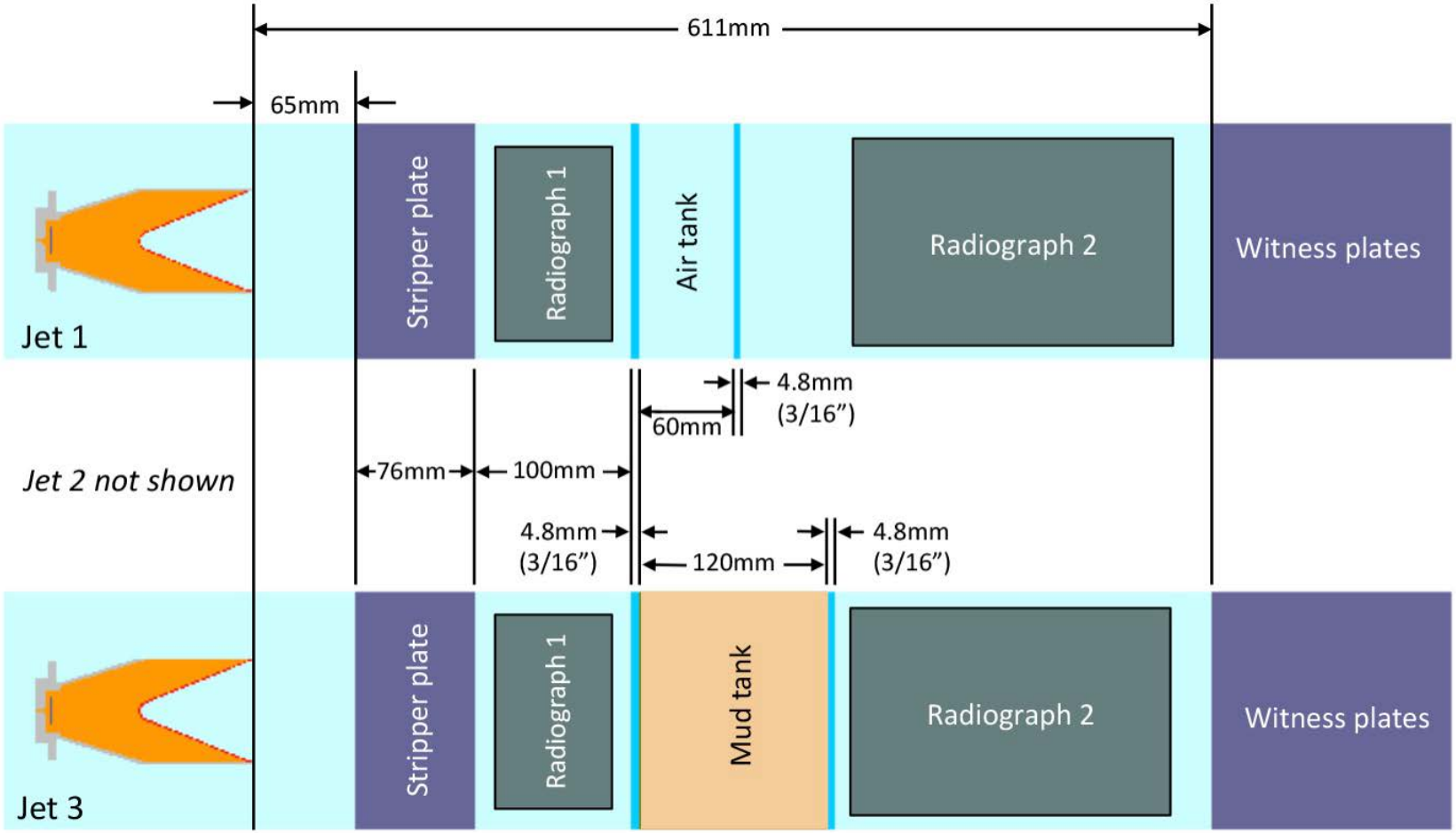


The major design unknown is jet erosion in drilling mud

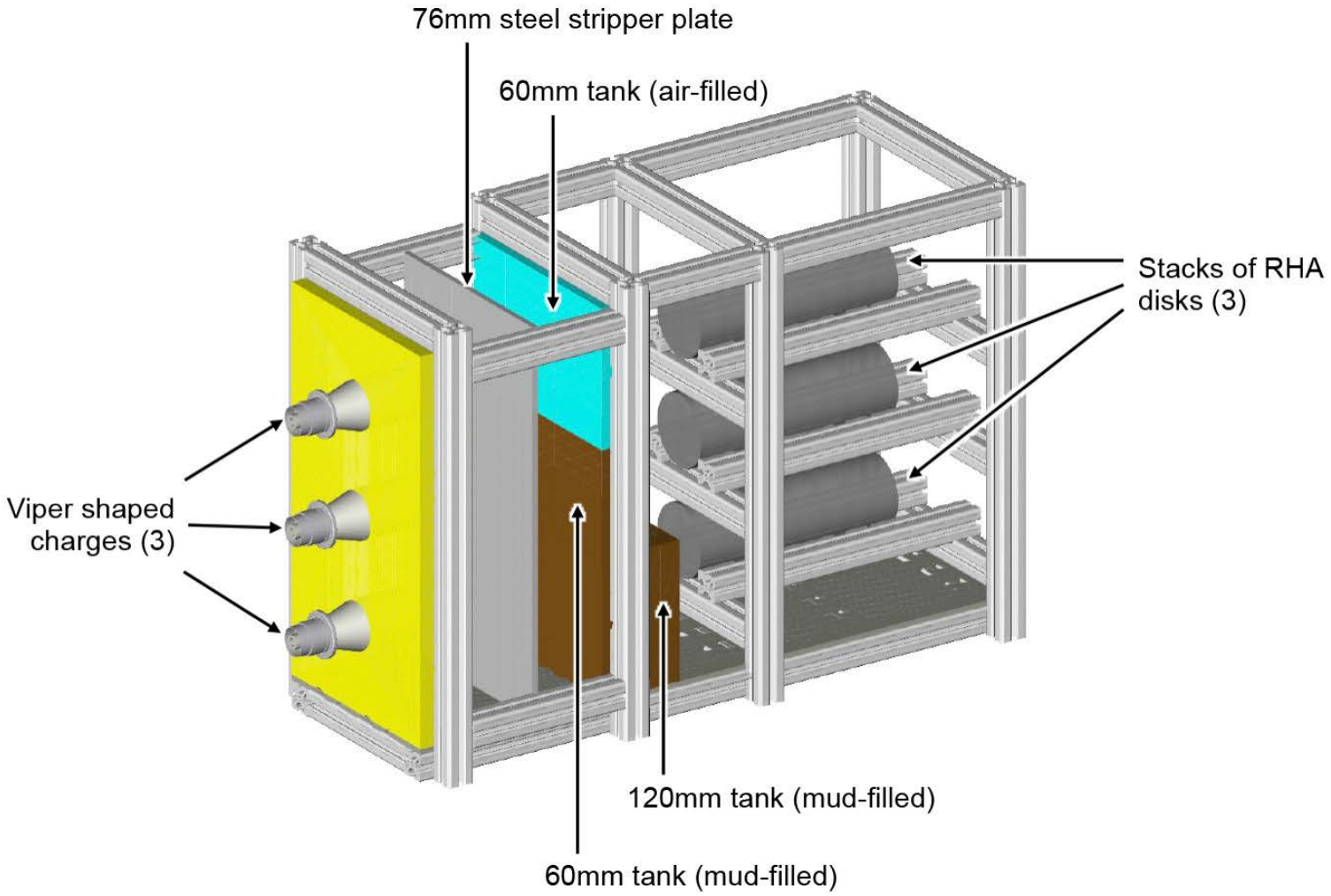
The well-characterized 65mm Viper shaped charge was selected for the erosion study

- The question to be addressed was whether our ALE3D simulations accounted for the necessary physics to predict jet erosion in drilling mud
- We assumed the physics was independent of the conical vs. linear configuration of a jet
- The experimental plan was to fire three Vipers simultaneously and observe jet tip propagation after emerging from air, 60mm and 120 mm of mud
- Because the Viper tip speed is much greater than the linear charges, a 76mm steel stripper plate was used to reduce the Viper speed from 9.2km/s to less than 6km/s

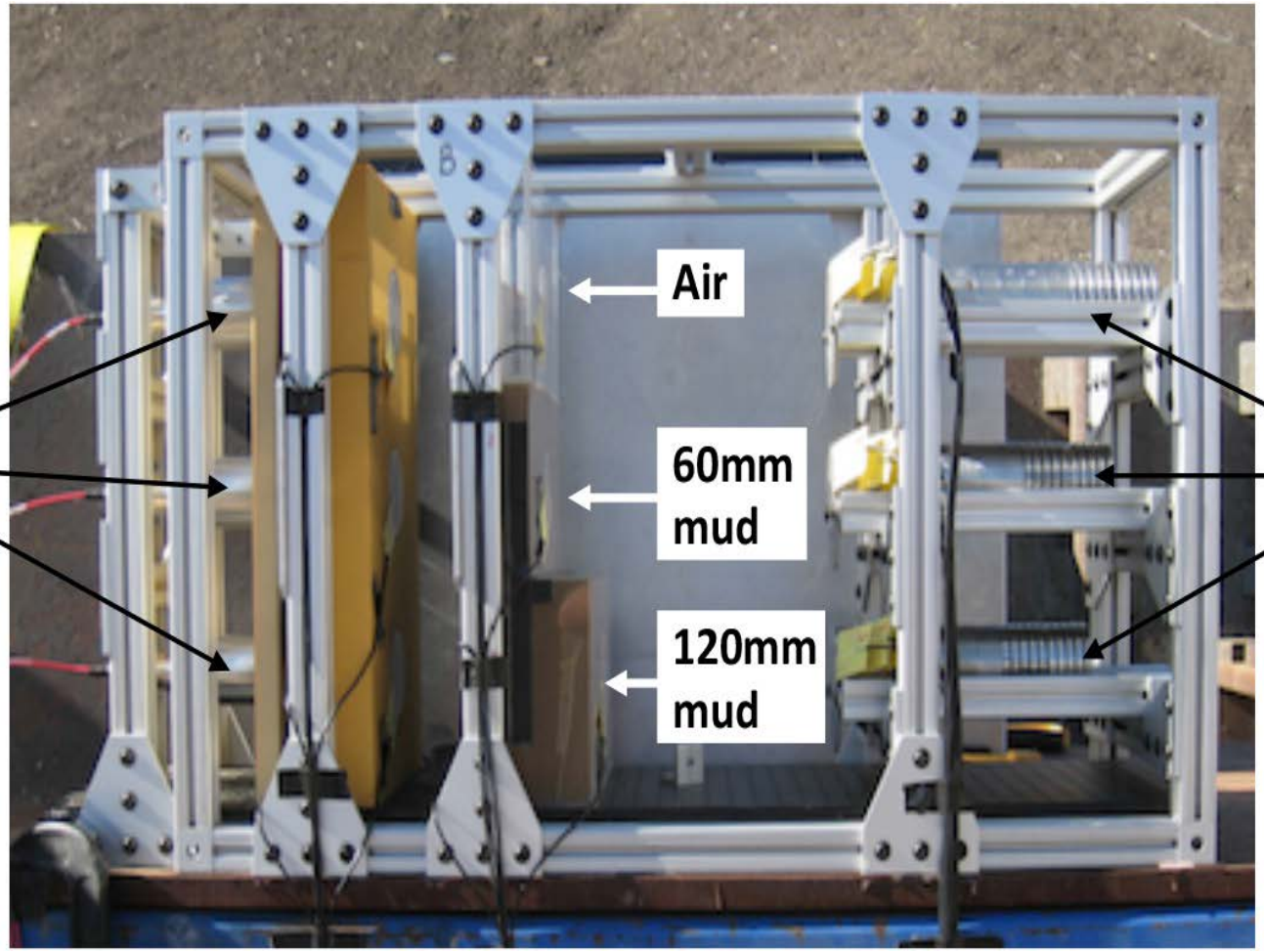
Dimensional layout of experiment as used in simulations



Schematic representation of vertical Viper array for erosion test



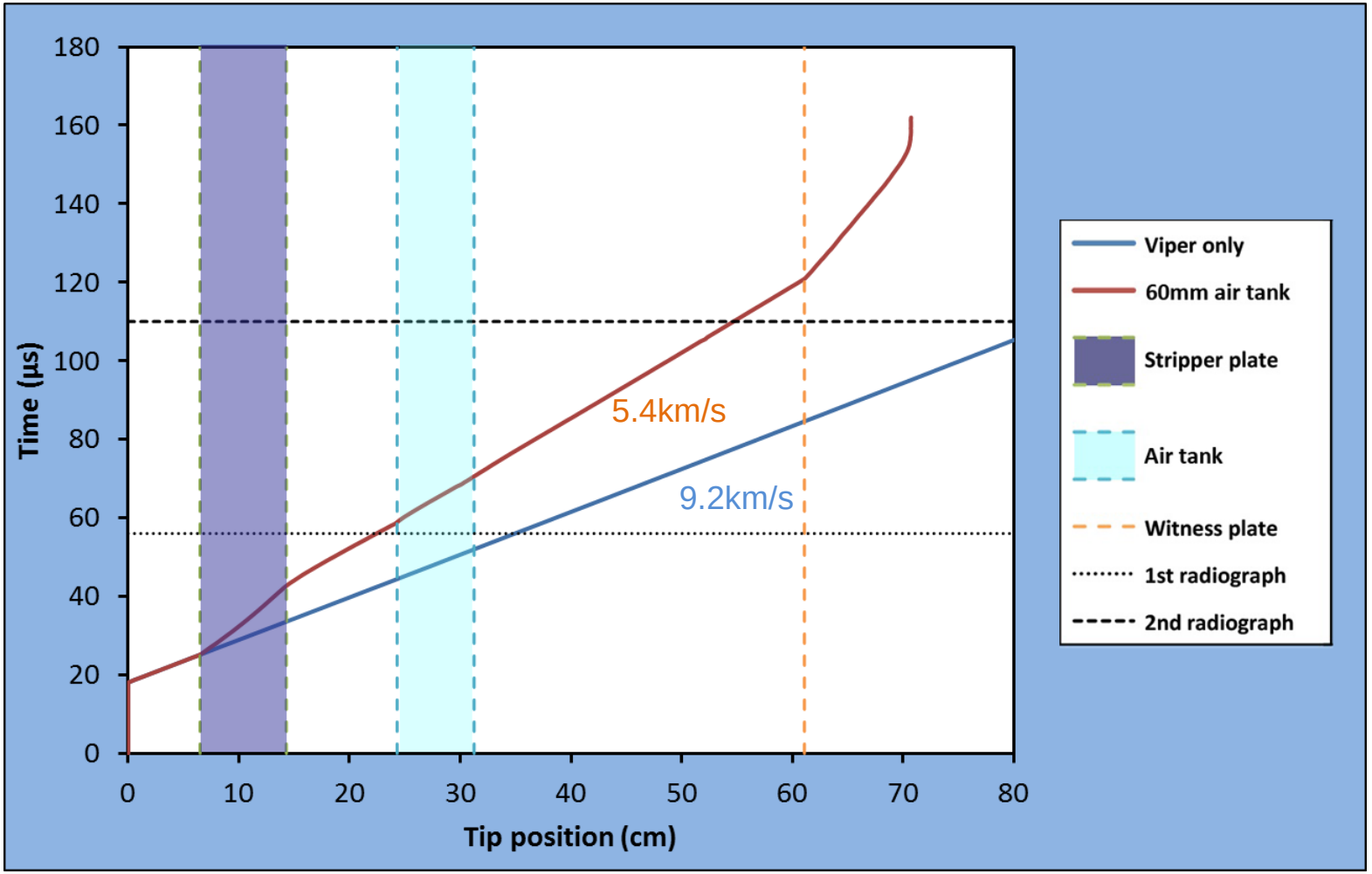
Experimental setup showing aircraft foam for charge support and mud tanks



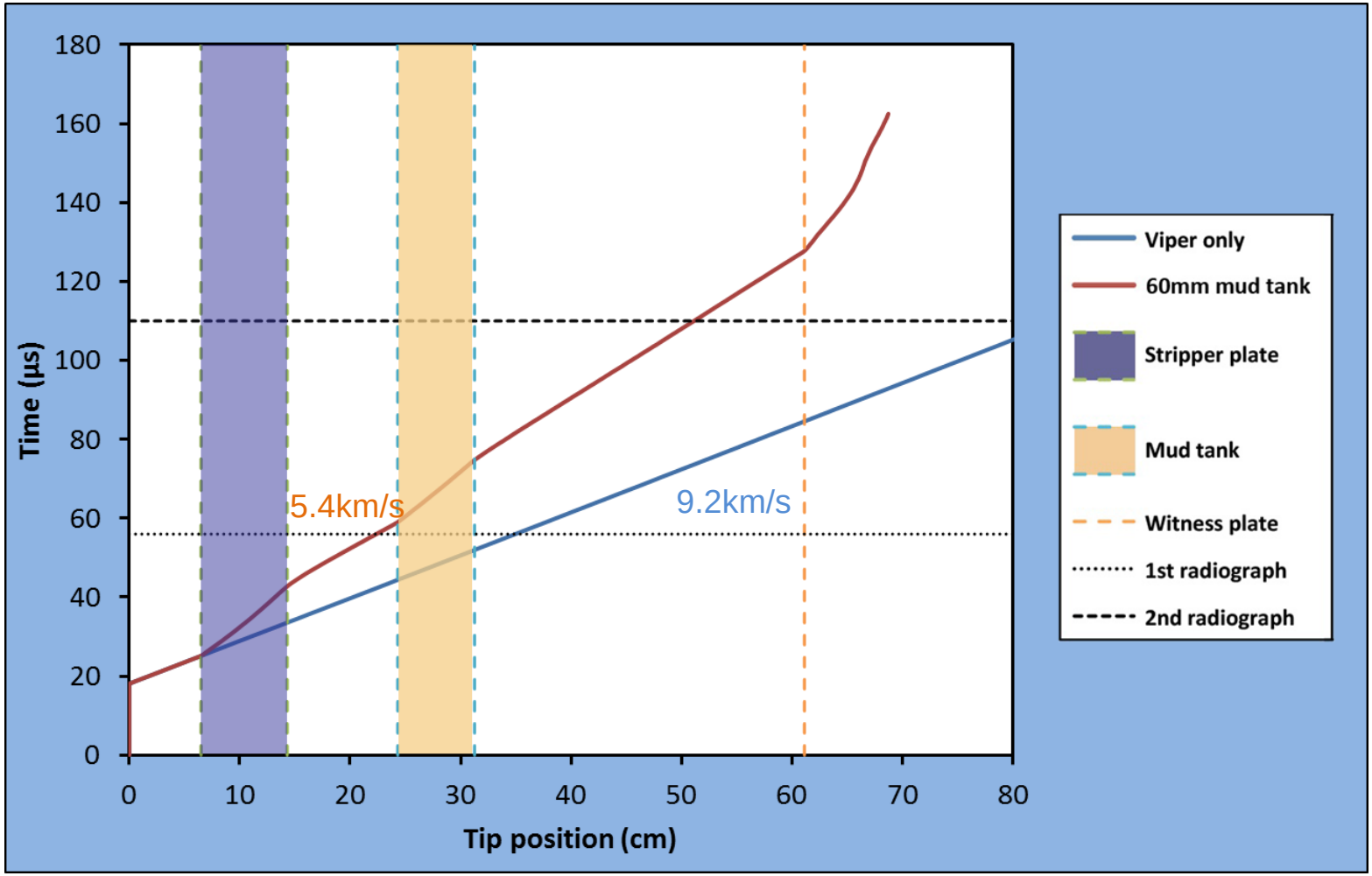
Viper charges

Witness plates

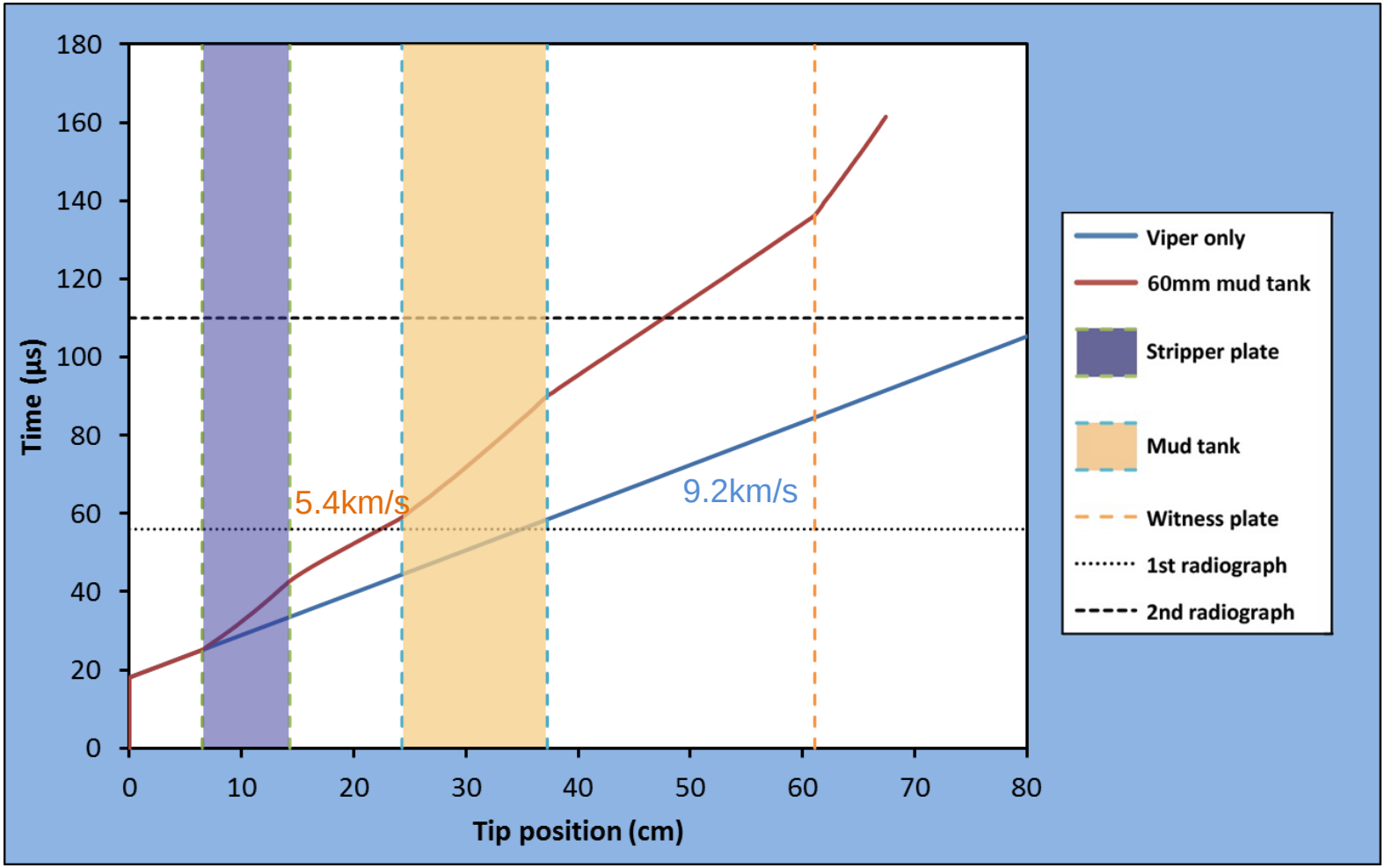
Simulated tip position for jet passing through 60mm air tank



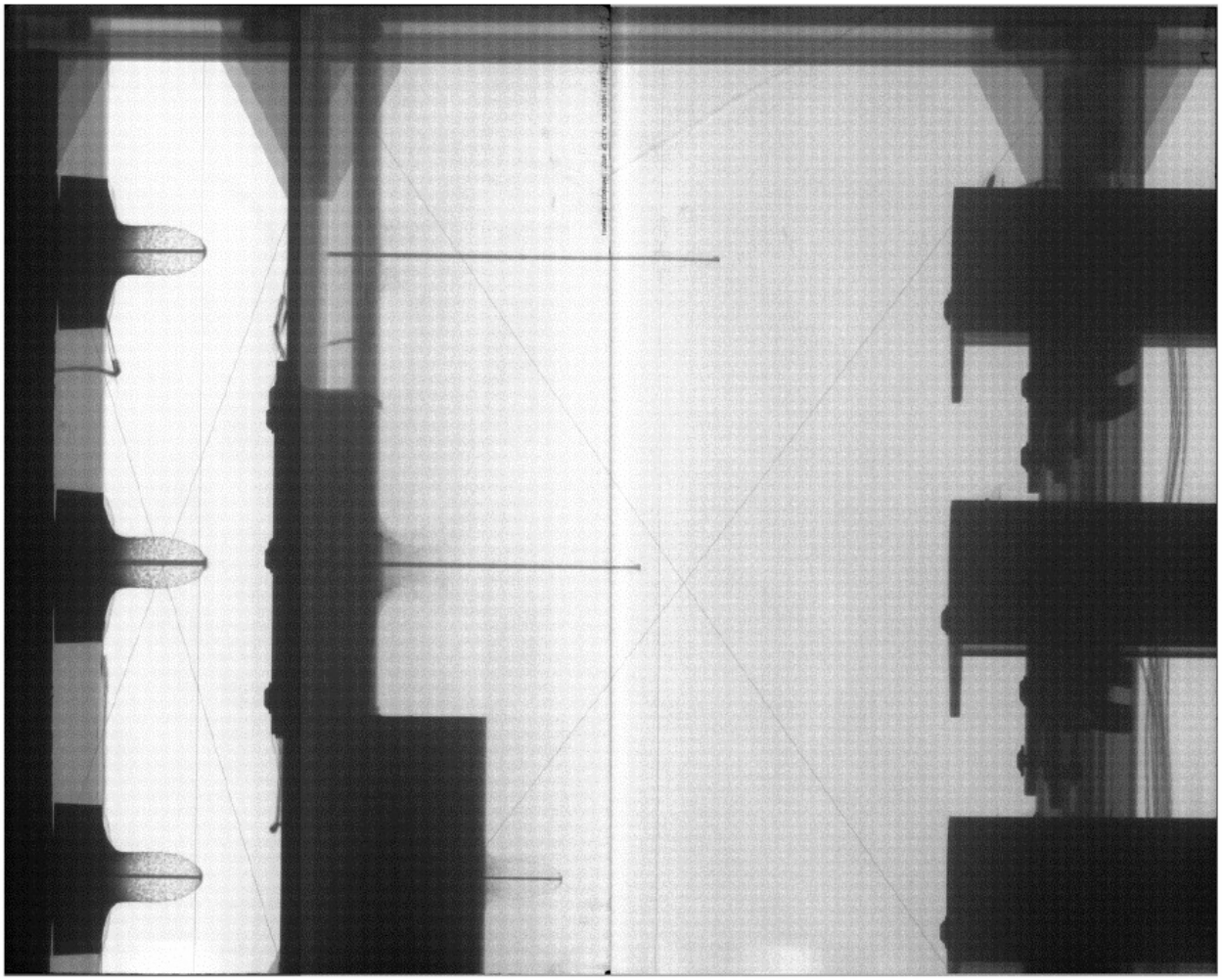
Simulated tip position for jet passing through 60mm mud tank



Simulated tip position for jet passing through 120mm mud tank



Jet radiographs before (56μs) and after (110μs) mud penetration



Test data show jet erosion simulations within 1.1mm (~3%) of data

Charge	Radio graph	Time (μs)	Position (mm)			Erosion (mm)		
			Sim.	Actual	% diff.	Sim.	Actual	% diff.
B1, 2, 3	Before mud	56	196.15	201.38	-2.59	-	-	-
B1	No mud	110	486.88	494.06	-1.45	-	-	-
B2	60mm mud	110	453.60	459.71	-1.33	33.3	34.4	-3.3
B3	120mm mud	110	417.51	425.73	-1.93	69.4	68.3	1.5

Conclusion: Modeling drilling mud as water with a density of 2g/cm^3 is adequate for accurate simulation of shaped charge jet erosion in velocity regime of interest to this problem

Thank you

Questions!